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Design for Health and Well Being: Knitted Products for Diabetics

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Abstract. This paper will discuss the design development, manufacturing and testing of knitted products maximizing the use of new innovations in Nano- technology and the integration of Phase Changing Materials specifically for diabetics. The project identified key aspects requiring design solutions to bring improvement to the circulatory problems with specific reference to the diabetic condition. Diabetics have particular difficulty in regulating their body temperature and this can result in the condition worsening, and resulting in loss of digits or limbs. The design of products to prevent the deterioration of the diabetic condition and to help those with limb loss was developed in collaboration with a Northern Ireland diabetic consultant, a product engineer and a knitwear designer. The fusion of ideas between the stakeholders resulted in the development and manufacture of a range of products that have been successfully tested at the yarn and fabric development stage and have been proven to maintain body temperature by either cooling or warming and therefore bring improvement to health and well-being. Whilst the product has a performance element the design ideas created desirable products that not only provided solutions to the brief but also resulted in products that had further market applications.

1. Introduction

The main focus of the paper is to investigate the outcomes and results of a project with a product designer, a diabetic consultant and a knitwear designer. This is in relation to the innovative developments in yarn technologies with particular reference to nanotechnology and phase changing materials. The needs of diabetics are clearly understood and articulated by a medical practitioner with many years of diagnostics and treatment. This expertise combined with the solution based and problem solving product engineer and the creativity, trend and market analysis of the designer. This triangulation and synergy in the group and research approach have all collaborated to produce a range of products specifically developed for diabetics. The products have been tested and are now commercially available.

Due to the research cluster identified target group were diabetics however it was recognized that there were potential benefits for a wider group of potential recipients. The range and diversity of products developed have included a cushion for a wheelchair, mattress, mattress cover, socks and garments including wraps. The emphasis of this paper is to investigate the garment designs and to assess if the design is fit for purpose combining an aesthetic quality that is equivalent to the technology involved.

As early as 2000 Bellucci identified that “the rapid progress in the field of nanoscience has been

increasingly driving the attention of the scientific community as well as society at large on the corresponding technological applications, which are the object of so-called nanotechnology. A strong interest in assessing the current state of the art of this fast growing field as well as stimulating research networking." [1].

The selection of the nanoscience technology to design yarns manufactured with phase changing materials captured the expertise in the team and created a platform for developing and product creation. These products had the potential to benefit and improve health and well-being. The project while investigating the importance of a 'medical' product wanted to create products that would also be 'desirable'.

The number of people diagnosed with diabetes in Europe is estimated at 60 million, and the IDF (International Diabetic Federation) estimates that 46.5 % of adults remain undiagnosed. According to a Who Report (Diabetes Care 27: 1047- 1053, 2004) the global prevalence of diabetes and the number of all ages with diabetes for the years 2000 and 2030, show that the numbers of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030, the IDF estimates that worldwide diabetes will rise to 642 million in 2040. The prevalence of diabetes is higher in men, but there are more women with diabetes than men. The most important demographic change to diabetes prevalence across the world appears to be the increase in the proportion of people >65 years of age. The findings indicate that the 'diabetes epidemic' will continue even if levels of obesity remain constant and that given the increasing prevalence of obesity, it is likely that these figures provide an underestimate of future diabetes. These figures and estimates show that the diabetic epidemic will bring financial burden to the health care worldwide [2].

The chronic nature of diabetes is costly for the health care system with both direct and indirect costs. The chronic nature of the condition and the gravity of its complications have meant that the indirect costs, such as the loss of productivity, disability, sick leave, early retirement and premature death are often higher than the direct costs. Studies in Latin America and America show that the tendency is 5 times higher (New*life*Outlook). Diabetes complications require hospitalization most of the time, and 50% of people with diabetes suffer from at least 1 complication. Hospitalization represents the biggest proportion of direct costs. It implies that admission to hospital, laboratory analysis, and the work of medical staff, specific therapies and investments [4-5].

Also according to New*life*Outlook, when you live with diabetes, it is not uncommon to feel cold or numb, especially in your extremities. Your core body temperature is closely tied to your metabolism, and since diabetes wreaks havoc on your metabolic processes, this in turn creates sweating, shivering, shaking far more than is evident in those without diabetes. Recent research in the National Health Service UK has uncovered the link between insulin and temperature. Insulin seems to work as an internal thermostat, helping to raise the core temperature by triggering the burning of 'brown fat' cells. Since insulin heals up the body it is no surprise that many type 1 diabetics (who have a depleted supply) should warm your body rather than cool it. However it is not quite so straightforward. One theory behind the chill of Type 2 diabetes centres on how long the insulin has been elevated. Chronically high insulin could exhaust the circuits that trigger the fat burning process, so the heat is never created, Since the body still needs heat for important metabolic reactions to take place, it begins to store insulating fat instead of burning fat. Extra fat on your body interferes with blood circulation, and that can leave your arms and legs, fingers and toes feeling particularly cold [3].

This difficulty in temperature regulation creates a tingling or burning pain that spreads from the fingers and toes up through the limbs. This can cause numbness, which can in turn lead to ulceration of the feet. Damage caused to the peripheral nervous system is termed, peripheral neuropathy. If the foot was to suffer any abrasions or cuts prevention of further damage or infection is of the utmost importance, as numbness from nerve damage can potentially cause one of the complications of diabetes that can result in limb amputation if the infection is not controlled [4].

It is this aspect of diabetes that the textile intervention seeks to reduce the possibility of either rubbing of the skin that might cause damage and further complications, and help regulate the body temperature through the investigation, development, design and manufacture of a series of products to help diabetics.

2. Experiments and methodology

As identified the target market were over 65, diabetic and while the products related to male and female the garments or wraps were tested with female diabetics. Market research, through qualitative and quantitative questionnaires was carried out with 100 females in this demographic; the same approach could be taken when assessing the products for mainly male sector and those products that are unisex. The focus of this research was to consider the level of satisfaction relating to the, weight, handle, comfort, maneuverability, colour and warmth.

2.1 Yarn

The yarn used to make the fabric was 5 ends of yarn (resulting 2/30's nm), this was polymers and copolymers with nanoparticles dispersed in the polymer matrix combined with 2 ends of Botanic fibres were integrated, cellulose yarn with the additive paraffin is refined plant oil. The reactive yarn technology created a micro heat accumulator with extraordinary latent heat potential. The phase changing material used is a micro composite with thermo regulating features, via direct spinning paraffin is embedded in a highly crystalline and tear resistant function this was combined with botanic fibres and integrated to use cellulose yarn with the additive paraffin is refined plant oil. [9]
Using the above series of processes to create yarns, they in turn were used to create a range of textile knitted garments including socks, wraps and seat covers. It is proposed based on previous research in the development of the yarns that textiles manufactured from these yarns can absorb excessive body-heat and when required, dispenses it again. Thus the temperature regulation is assured, providing extraordinary wearing comfort and excellent skin surface microclimate.

2.2 Structures

The fabrics were created on two different knitting machines, both weft knitting. The socks were produced on a Santoni sock machine (circular) and the wraps were produced on Shima Seiki flatbed machines. The garments used the polymer and copolymer yarns, combined with the cellulose yarns and were knitted on 12 gauge machines. The following structures were used to create the garments; all the yarn was kept the same throughout.

2 colour jacquard – stripe backing
3 colour jacquard – birds-eye backing 2 colour jacquard – reverse jacquard 3 colour jacquard – reverse Jacquard
Tensions were adapted to the stitch structure to enable correct qualities of knitting outcome.

2.3 Colour

Colour selection was an important part of the project. It was not only important to use the intelligent yarns to maximize comfort and promote temperature regulation. The methods for selecting colours was trend led through the use of WGSN (Worth Global Style Network) trend forecasting website, Lenzing colour predictions and Trend tablet. Market knowledge and understanding of colour was important for the end product selections to be effective and desirable, the investigation into colour was trend analysis and how colour selections were made. Colour (Scully and Johnston, 2012) has become increasingly important in the development, marketing and sales of goods, this is especially true for the fashion business and the consumer has become accustomed to a wide range of inspirational colour choices in apparel. According to the International colour authority "Colour comes before style and price, and is the first factor to which the customer responds" and is therefore important in satisfying the not only the medical intervention but the desirability to select but also to continue to choose to wear the product and the emotional response of something that is not simply a medical solution to a diagnoses.

Questionnaires were given to the target group of 100 female diabetics in the > 65 age range. Questions covered the following aspects of the wraps:

- Comfort in terms of weight in garment design when wearing for 3 hours
- Comfort in terms of maintaining body temperature (when donning garment design for approx. 3 hours).
- Comfort in terms of satisfaction of colour garment design and preference identified Comfort in terms of sensory satisfaction in garment design and handle – preference identified.
- Comfort in terms of maneuverability of design (for approx 3 hours donning)
- The wraps due to the structure of the garments and draping of the garment designs did have a variance of weights, these were as depicted in Table 1.

Table 1: Weight of Wraps

Results	Wrap 1	Wrap 2	Wrap 3	Wrap 4	Wrap 5
Weight	317.5g	330.0g	516.5	315.2g	528.0g

3. Results and Discussions

The following wraps were those selected for review and testing within the target group

Figure 1. Wrap 1 (Red, cream and Grey) and detail, wrap in 3 colour jacquard with birds-eye backing.

Figure 2. Wrap 2 (Blue, purple and cream) 2-colour jacquard birds-eye reverse

Figure 3. Wrap 3 (Grey, cream and black) 2-colour jacquard stripe reverse

Figure 4. Wrap 4 (Green, cream and black) 3 colour reverse (interlock) jersey structure

Figure 5. Wrap 5 (Multi-coloured) 3-coloured jacquard birds-eye reverse

Table 2. Quantitative Results of Questionnaires for preference and comfort selection. The numbers indicate the selected wrap identified via the questionnaires.

Wrap	Weight	Warmth	Colour	Handle	Movement
Wrap 1	22	19	17	17	19
Wrap 2	17	15	19	18	20
Wrap 3	10	12	21	18	12
Wrap 4	35	29	32	30	23
Wrap 5	16	25	11	17	26

The most popular wrap selected was Wrap 4 overall (in 4 elements) for weight, warmth, colour and handle but not for movement, that accolade went to wrap 5.

The results show that the preferred weight was the reverse interlock stitch, which has the highest weight out of all of the wraps due to the stitch structure. And was the most comfortable after continuously wearing for 3 hours. So the heaviest weight, the wrap containing the most yarn was the most warm. This structure also was the most pleasing in terms of handle, again due to the stitch structure the reverse interlock stitch. The most preferred wrap for movement was wrap 5 and this was the most comfortable to put on. The preferred colour was wrap 4, the green cream and black combination, all of the yarn content remained the same the difference came through stitch structure and style. The predicted colours in this target group were for purples according to trend information (WGSN, 2016) however the green wrap was the most on-trend colour in the selected range and the most desirable. Qualitative feedback is clear that colour was of utmost importance followed by the quality of handle and the warmth and comfort of the garment. The was an understanding that there were specific reasons to wear the garment, and that it would help temperature regulation, but it was clear by the comments that the majority would not wear a garment purely for functional value [7].

4. Conclusion

Therefore the 'diabetic epidemic' creates the necessity to reduce the impact of deterioration in the disease, to increase the diabetics' wellbeing but also to reduce direct and indirect costs. Interventions through the use of phase changing materials and the developments in nano technology can create yarns suitable to address those body-regulating issues that are prevalent in diabetics. However it is not enough to address this with medical textiles, there needs to be an element of market awareness and design, to provide this ever-growing group with a desirable product. The desirability of the product needs to meet all the requirements to ensure the success of the product regarding the key elements of comfort, weight, warmth, movement and colour. Further research needs to be developed for menswear and for other age demographics; this research was aligned to the UK market, with specific reference to the Northern Ireland region.

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